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A cost effective analysis of a laparoscopic versus an open left lateral sectionectomy in a liver transplant unit

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Abstract

Introduction: This study aimed to assess the cost effectiveness of a laparoscopic left lateral sectionectomy (LLLS) compared with an open (OLLS) procedure and its role as a training operation as well as the learning curve associated with a laparoscopic approach.

Method: Between 2004 and 2013, a prospectively maintained database was reviewed. LLLS were compared with age- and sex-matched OLLS. In addition, the outcomes of LLLS with a consultant as the primary surgeon were compared with those performed by trainees.

Results: Forty-three LLLS were performed during the study period. LLLS was a significantly cheaper operation compared with OLLS (P = 0.001, £3594.14 versus £5593.41). The median hospital stay was shorter in the laparoscopic group (P = 0.002, 3 versus 7 days). No difference was found in outcomes between a LLLS performed by a trainee or consultant (operating time, morbidity or R1 resection rate). The procedure length was significantly shorter during the later half of the study period [120 versus 129 min (P = 0.045)].

Conclusion: LLLS is a significantly cost effective operation compared with an open approach with a reduction in hospital stay. In addition, it is suitable to use as a training operation.

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Introduction

A laparoscopic liver resection (LLR) was first reported in 1992[1] and has been gaining popularity over the last two decades, in 2009 there were almost 3000 laparoscopic resections reported.[2] A meta-analysis of the retrospective studies found short-term benefits and comparable long-term outcomes between laparoscopic and open liver resection.[3]

There are a number of studies comparing a laparoscopic left lateral sectionectomy (LLLS) with its open (OLLS) equivalent but relatively few compared the cost effectiveness of each approach. In addition, these studies were small and featured a combination of anatomical and non-anatomical resection or were not case matched.[4–9] (Table 1).

LLLS is often considered to be the first-line approach for lesions within segments II and III, as is the case in our centre. Given the increasing volumes of LLR being performed it is important that higher surgical trainees gain adequate exposure to laparoscopic resection. As LLR requires advanced laparoscopic skills coupled with liver resection expertise, training opportunities can be limited. There was only one study assessing LLLS as a training operation whereas others were compared in *ex vivo* models.[10,11]

This study looked at the cost effectiveness of LLLS compared with age- and gender-matched OLLS. In addition, the role of LLLS as a training operation was assessed.

This study was presented as a poster presentation at AUGIS 2014, 18–19 September, Brighton, UK.

Methods

Between August 2004 and October 2013, a prospectively maintained database of liver resections for benign and malignant disease was reviewed. This database contains information on type of resection, co-morbidity, the use of the Pringle manoeuvre and length, operating time, transfusion requirements, length of stay (LOS), complications, pathological information and follow-up of

Table 1 Summary of costing analysis in laparoscopic liver surgery

Authors	Year	Country	Numbers in each group (no. LLS)		Resection	Matched	Outcome
			Laparoscopic	Open			
Cannon *et al*.[4]	2013	US	57 (17)	41 (5)	Combination of Right/Left hepatectomy and Left lateral and Right posterior sectionectomy	No	In favour of laparoscopic approach
Vanounou *et al*.[5]	2010	US	44	29	Left lateral sectionectomy	No	In favour of laparoscopic approach
Dokmak *et al*.[6]	2013	France	31	31	Left lateral sectionectomy, Benign	Yes	In favour of laparoscopic approach
Abu Hilal *et al*.[7]	2013	UK	84 (46)	65 (19)	Right hepatectomy and left lateral sectionectomy	No	In favour of LLLS, neutral LRH
Polignano *et al*.[8]	2008	UK	25 (10)	25 (9)	Mixture of bisegmentectomies, segmentectomies and atypical	Yes	In favour of laparoscopic group
Kim *et al*.[9]	2011	South Korea	11	11	Donor left lateral sectionectomy	No	No difference in cost

LLS, left lateral sectionectomy; LRH, laparoscopic right hemihepatectomy; LLLS, laparoscopic left lateral sectionectomy.

patients undergoing liver resections within our unit. LLLS performed were identified and age-, sex- and operation matched to OLLS within the same time period. Our technique for performing LLLS has been described previously.[12]

Costing analysis

Unit costs were obtained for theatre usage per hour, high-dependency unit (HDU) stay, intensive care unit (ICU) stay and ward stay for a 24-h period. The cost of additional disposable instruments used in theatre was also calculated. The unit costs used were as follows: £400 theatre/h, £700 HDU/day, £1716 ICU/day, £220 ward bed/day. Disposable instruments were costed as follows: £310.91 CUSA (Valleylab, Boulder, CO, USA), £443 Harmonic scalpel (Ethicon, Cincinnati, OH, USA), £416 ENSEAL G2 Articulating Tissue Sealer (Ethicon), £112.94 Endo GIA (Covidien Surgical, Norwalk, CT, USA), £167.86 reload for 45 mm vascular Endo GIA (Covidien Surgical), Endo Clip ML – £97.87 (Covidien Surgical), £44.40 trocar (Ethicon), Tisseel tissue glue – £360 (Baxter International Inc., Westlake Village, CA, USA), Laparoscopic Duplo Tip applicator – £25.75 (Baxter International Inc.), open Tisseel tissue glue + applicator £372.80 (Baxter International Inc.), TA30V Stapler + reload (Covidien Surgical), £20.50 Surgicel (Ethicon) and £88 Tachosil (Takeda Austria GmbH, Linz, Austria). These data were then used to calculate the total cost for the admission.

The two groups were compared with regards to primarily cost and LOS. Secondary outcomes were morbidity, mortality, tumour size, positive resection margins (tumour within 1 mm), disease-free and overall survival.

Training

LLLS with a trainee as the primary operator were compared with LLLS with a consultant as the primary operator. The outcomes compared were operating time, requirement for blood transfusion, conversion, LOS, complications and R0/R1 resection.

Learning curve

The effect of time period on LLLS within our unit was also assessed by comparing the first 5 years, representing the learning curve, and the last 4 years, representing the consolidation of knowledge. Outcomes measured were operating time, transfusion requirements, LOS, transfusion requirements, complications and R0/R1 resection.

Statistical analysis

Statistical analysis was performed using SPSS version 19 (SPSS Inc., Chicago, IL, USA). Data were expressed as the median (range) unless stated otherwise. Chi-squared and Mann–Whitney *U*-test were used as appropriate. A *P*-value of <0.05 was considered significant.

Results

One hundred and ten LLR were performed during the study period for a combination of benign and malignant disease of which 43 were LLS. Nine out of 110 were major resections (5 right hepatectomies, 4 left hepatectomies) and 58 out of 110 non anatomical resections. The indications for LLR are summarized in Table 2. 53% were female with a median age of 61 years (21–87). The median operating time was 120 min (range 40–200) with only 1 (2%) postoperative complication. No patients required an intra-operative transfusion. The median LOS was 3 days (range 1–19). Three patients (9%) had an R1 resection with the remaining 30 having R0 resections. There were 10 resections for benign disease.

Table 2 Indication for surgery

	OLLS	LLLS
Benign	7	10
CRLM	25	20
HCC	4	6
Cholangiocarcinoma	2	3
Other Malignancies	5	4
R1 Resections	5	3

OLLS, open left lateral sectionectomy; LLLS, laparoscopic left lateral sectionectomy; CRLM, colorectal liver metastases; HCC, hepatocellular carcinoma.

Cost analysis

Patient age and sex between the open and laparoscopic groups were identical. Operating time was comparable between the two groups ($P = 0.203$, 120 min versus 120 min). LOS on the HDU was shorter in the laparoscopic group ($P = 0.03$, 0 versus 2 days) but the ICU stay was comparable. The LOS on the ward and overall LOS were significantly lower in the laparoscopic group being 3 versus 5 days and 3 versus 7 days ($P = 0.04$ and 0.002), respectively. Theatre costs were comparable between the laparoscopic and open groups (P = 0.203). Instrument costs were significantly higher in the laparoscopic group ($P = 0.03$). The ratio of benign to malignant disease, R0 to R1 resection, closest resection margin and maximum tumour diameter were all comparable. Patient characteristics and outcomes are summarized in Table 3.

Training analysis

Of the 43 LLLS performed during the study period 31 (72%) were performed by a consultant as the primary surgeon and 12 were performed by a trainee. There were no significant differences between the consultant group and trainee group with regards to procedure length, R1 resection rate and complication rate. The two groups are compared in Table 4.

Outcomes in different time periods

There were 18 LLLS performed between 2004–2009 and 25 between 2010–2013. Patient demographics were comparable. The procedure length was shorter in the second time period ($P = 0.045$, 129 min versus 120 min). LOS was comparable. The R1 rate was also comparable. Patient demographics and outcomes between the two time periods are summarized in Table 5.

Discussion

The benefits of laparoscopic versus open surgery have been well documented across a variety of surgical specialities and include shorter hospital stay, reduced post-operative pain and improved cosmesis.[13–15] In the present financial climate cost of healthcare is a major issue with cost effectiveness usually being assessed prior to implementation of a service.[16] Our study has shown LLLS to be a significantly cost effective than its open equivalent.

The two groups were comparable with regards to age, gender, tumour size and R1 resection rate. In addition, there was no significant difference between procedure length, ICU stay and post-operative complications. The overall LOS, HDU stay and ward stay were significantly shorter in the laparoscopic group. This equated to a comparable cost on theatre time. The cost of instruments was significantly higher in the laparoscopic group however this was offset by the significantly greater bed costs in the open group. Ultimately this led to the overall cost of LLLS being significantly less than OLLS.

There are a number of previous studies that have looked at cost effectiveness between laparoscopic and open liver resection. These studies often compare a combination of major and minor resections, have a smaller number of patients than ours or do not compare laparoscopic matched to open cases. Our findings, from a larger matched series, support the findings of these other studies with regards to the higher instrument costs being offset by the lower cost associated with a shorter hospital stay in LLLS. We calculated a cost advantage of almost £2000 per case which in our series gives a total saving of approximately £86 000 in favour of the laparoscopic group. A large proportion of laparoscopic resections in our unit are non-anatomical and although we have not directly compared the cost between laparoscopic and open non-anatomical resection we would anticipate a similar saving in favour of the laparoscopic group. This adds further weight to the argument that LLLS should be the gold standard for suitable lesions, both benign and malignant, in segments II and III and for non-anatomical resections in the anterior segments of the right hemiliver.

There has been a rapid expansion of LLR in recent years and it is important that hepatobiliary trainees gain the necessary exposure. Many skills for laparoscopic procedures can be learnt on simulators and the skills are transferable to the operating theatre.[17,18] However, reports of *ex vivo* training models are limited and we were only able to find one study looking at the outcomes of trainees performing LLLS.[10,11] Our study is in agreement with *Hasegawa et al.* that LLLS is a safe and feasible operation for learning LLR with comparable outcomes between consultant and trainee as the primary surgeon.

The increasing volume of LLR being performed is evident when we compare the two eras with more LLLS being performed in the shorter second era. The learning curve is also evident with the reduction in procedure length.

The main limitation of the present study is the retrospective nature. At present there are no randomized controlled trials comparing cost effectiveness of LLLS and OLLS and further studies are required to consolidate the findings of the present study.

Conflict of interest

None.

Funding

None.

Table 3 Outcomes for LLLS versus OLLS

	LLLS Group (n = 43)	OLLLS Group (n = 43)	P value
Age	61	61	0.962
Gender (m : f)	1:1.2	1:1.2	1.00
Procedure length (min)	120 (40–200)	120 (45–220)	0.203
Post-operative complications (Clavien–Dindo classification)	1 (1 bile leak-IIIA)	5 (2 wound infection- I & II, 2 bile leaks – IIIA, 1 MI-V)	0.09
90 day mortality	0	1	0.314
HDU stay (days)	0 (0–4)	2 (0–10)	0.03
ICU stay (days)	0 (0)	0 (0–6)	0.181
Ward stay (days)	3 (1–17)	5 (2–45)	0.04
Length of stay (days)	3 (1–19)	7 (4–59)	0.002
Theatre costs	£826.13 (219.98)	£775.17 (234.57)	0.203
Instrument costs	£1567.55 (314.11)	£1184.65 (194.49)	0.03
Bed costs	£1200.47 (1005.98)	£3633.58 (4024.48)	0.001
Total cost	£3594.14 (1096.22)	£5593.41 (4068.34)	0.001
Size of largest tumour (mm)	34.7	39.5	0.480
Closest resection margin (mm)	10.7	7.4	0.306

OLLS, Open Left lateral sectionectomy; LLLS, Laparoscopic left lateral sectionectomy; HDU, high dependency unit; ICU, intensive care unit.

Table 4 Outcomes for consultant versus trainee

	Consultant group (n = 31)	Trainee group (n = 12)	P value
Age	60 (21–85)	70 (36–85)	0.129
Gender (m : f)	1:1.4	1.4:1	0.334
Procedure length	120 (40–200)	120 (90–180)	0.717
Complications	1	0	0.529
R1 Resections	2	1	0.828
Length of stay	3 (2–8)	4 (1–19)	0.302

Table 5 Summarizing the outcomes between 2004–2009 and 2010–2013

	2004–2009 (n = 18)	2010–2013 (n = 25)	P value
Patient age	61 (36–85)	60 (21–85)	0.579
Gender (m : f)	1:1.25	1:1.1	0.818
Procedure length	129 (90–200)	120 (40–150)	0.045
Trainee first surgeon	4	8	0.668
Length of stay	3.5 (2–8)	3 (1–19)	0.639
R1 resection	1	2	0.756

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